DOCUMENT RESUME

ED 135 651 SE 022 138

AUTHOR Rowe, Ronald
TITLE The Philosophic Consistency of Science Teachers' Opinions About the Structure of Scientific Laws and Theories.
PUB DATE Mar 77
NOTE 15p.; Paper presented at the annual meeting of the National Association for Research in Science Teaching (50th, Cincinnati, Ohio, March 22-24, 1977)

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS Educational Research; *Fundamental Concepts; Opinions; *Philosophy; Science Education; *Science Teachers; *Scientific Concepts; Secondary School Teachers; *Surveys
IDENTIFIERS Research Reports

ABSTRACT

Investigated was how science teachers conceptualize the nature of science. An understanding of the nature of scientific laws and theories was used as an indicator of the broad "nature of science" concept. Fifty junior high and middle school science teachers in Wisconsin were randomly chosen to respond to a Likert-type opinionaire developed by the author. The opinionaire contained 56 statements about laws and theories, representing publised viewpoints and logical alternatives of five scientific philosophers (Carnap, Hempel, Popper, Kemeny, and Lachman). Statements were grouped for analysis. Data analysis indicated that the teachers held divergent opinions concerning the structure of laws and theories, and that they were philosophically inconsistent in their responses (with statements identified with Lachman receiving the greatest degree of endorsement and those identified with Popper the least). (CS)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. Nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

ED135651

U S DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

THE PHILOSOPHIC CONSISTENCY OF SCIENCE TEACHERS' OPINIONS ABOUT THE STRUCTURE OF SCIENTIFIC LAWS AND THEORIES

RONALD ROWE

Department of Education
Beaver College
Glenside, Pennsylvania 19038

SE 022 138

Introduction

The development in students of an understanding of the nature of science has frequently been mentioned in published articles about the goals of science education and in the lists of objectives written by science teachers and developers of instructional materials. The problem of analyzing what is meant by the concept "the nature (or structure) of science" has been the focus of studies by Schwab (1960), Robinson (1964), Connelly (1968), Herron (1971) and others. Many of the investigations in this area were based upon original research reports of scientists or the writings of philosophers of science. Subsequent to the publication of these studies, serious questions have been raised about the adequacy of the models of "the nature of science" presented in the curricular materials and the cognitive meanings that classroom teachers associate with this concept.

If it may be assumed that the science teacher's conceptualization of the nature of science will significantly influence his students' image of science, then the determination of <u>how</u> science teachers conceptualize the scientific enterprise becomes an important task. This is a problem that has not yet been resolved. Previous investigations

have been designed to assess whether teachers possess an adequate "understanding" of the nature of science, but they have not led to a resolution of how teachers view this concept. Do science teachers have convergent or divergent viewpoints about the nature of science? Do science teachers conceptualize "the nature of science" in a way that is consistent with the viewpoints of modern philosophers of science? Data from previous research efforts have not yielded answers to these questions. Two possible explanations have been advanced to account for the present uncertainty in this area:

(1) the "nature of science" is such a broad and diverse concept that any single investigation designed to measure "understanding" of the entire concept may not be feasible, and

(2) the available instruments used by previous researchers frequently presented a model of the scientific enterprise based on the views of only one or two scholars, and failed to represent the many diverse opinions that exist in the philosophic community.

The purpose of the current study, therefore, was to determine science teachers' conceptualizations of the nature of scientific laws and theories, a subset of the broad

"nature of science" concept, in depth. In addition, it was considered desirable to attempt to determine whether the teachers held viewpoints about laws and theories that were consistent with those held by several modern philosophers of science. The facilitation of this inquiry required the construction of a new instrument, based on the writings of five philosophers who reflect the present diversity of opinion in this field.

The Study

The method utilized was that of a descriptive survey, and the data were analyzed and reported in terms of descriptive statistics. An opinionnaire containing closed-form items was constructed. The instrument contained a series of statements about laws and theories to which respondents were instructed to choose one of four modified Likert-type responses: agree, disagree, don't know, or unclear. Most of the statements were written to reflect the published positions of five contemporary philosophers of science: Rudolf Carnap (1966), Carl Hempel (1966), Sheldon Lachman (1960), John Kemeny (1959), and Karl Popper (1962). The remaining statements were included to provide logical alternatives to the other statements.

The final set of 42 statements identified with the five philosophers was selected from a larger initial list

of 105 statements, with elimination and revision of statements based on the judgment of a panel of experts and a pilot study conducted with a group of prospective secondary school science teachers. The statements were grouped for analytical purposes according to the following scheme:

(1) definitions and characteristics of laws and theories,

(2) the linguistic* structure of laws and theories,

(3) the formulation of laws and theories,

(4) the functions of laws and theories, and

(5) the corroboration of laws and theories.

Response data were collected from 50 science teachers who were randomly selected from a total population of 1056 teaching in the public middle and junior high schools in the state of Wisconsin during the autumn of 1975.

Data analysis included computation of frequencies and percentages of response within each response category, item analysis to identify statements eliciting high ratios of disparate responses, and identification of philosophers associated with statements receiving high and low percentages of "agree" responses. Data were tabulated to show

---

*The term "linguistic" is used here to refer to the types of concepts found in laws and theories, not the science of languages.

the frequency of "agree" responses to the total set of statements identified with each philosopher. This permitted analysis of the philosophic consistency of the teachers as a group and also allowed an individual "philosophic profile" to be generated for each teacher.

Results

Teachers in the sample chose "agree" responses most frequently for the following statements about scientific laws and theories:

A law is a statement of knowledge that -

(1) expresses consistency among observations of nature (88% of the teachers),

(2) may contain both empirical and theoretical concepts (68%),

(3) is developed directly from facts (78%),

(4) can be formulated inductively (68%),

(5) can be used to explain and predict facts (86%), and

(6) may be considered to be a true statement (82%).

A theory is a statement that -

(1) is more credible than a hypothesis but less than a law (80%),

(2) is a potential law (86%),

(3) is propositional (86%),

(4) was originally hypothetical, but has become accepted by the scientific community (86%),

(5) contains both empirical and theoretical concepts (70%),

(6) is based upon known facts and laws (62%),

(7) is an extrapolation from facts (74%),

(8) can be formulated inductively (82%),

(9) can be creatively formulated and deductively tested (56%),

(10) can explain facts (64%) and predict new facts and laws (84%),

(11) can be proved to be either true or false (72%), and

(12) can only attain different degrees of credibility (82%).

Statements eliciting the highest ratios of disparate responses* were:

(1) a theory is developed directly in the human mind (0.49),

(2) there is only one type of law: universal (0.48),

(3) laws can only describe factual events (0.48), and

(4) theories can be used to explain laws (0.47).

---

*This ratio was obtained by dividing the smaller frequency of either "agree" or "disagree" responses to the statement by the total "agree" plus "disagree" responses, and had a maximum value of 0.50.

Statements that most frequently elicited either "don't know" or "unclear" responses were:

(1) there are three types of laws: universal, probabalistic and causal (56% of the teachers),

(2) there are two types of laws: universal and probabalistic (54%), and

(3) there is only one type of law: universal (42%).

Table I reports the distribution of the number of "agree" responses made by the teachers to all of the statements identified with each of the five philosophers and to the statements provided as logical alternatives. The mean number of "agree" responses made by the teachers to the 18 statements identified with Carnap was 10.4, or 57.8 percent of the total. Corresponding distribution means for the remaining philosophers were: Hempel, 11.6 or 61.1 percent; Kemeny, 14.3 or 65.0 percent; Lachman, 8.2 or 68.3 percent; Popper, 6.7 or 44.7 percent; and logical alternatives, 2.0 or 28.6 percent. These results indicate a higher percentage of teacher agreement with the total set of "Lachman statements" than with statements identified with Kemeny, Hempel, Carnap, Popper, or none of the philosophers.

It may be seen that the teachers did not endorse the views about laws and theories associated with any one of the five philosophers to the exclusion of the others. With regard to specific aspects of laws and theories, the respondents varied considerably in their philosophical

Table I

Frequency of Teachers' Selection of AGREE Responses to Statements Identified with Philosophers of Science

	Philosophers of Science					
	Carnap	Hempel	Kemeny	Lachman	Popper	None
Total Statements	18	19	22	12	15	7
Number of AGREE's	n	n	n	n	n	n
20	--	--	1	--	--	--
19	--	--	--	--	--	--
18	--	--	2	--	--	--
17	--	--	8	--	--	--
16	--	3	4	--	--	--
15	1	6	11	--	--	--
14	3	7	12	--	--	--
13	9	4	5	--	--	--
12	8	9	2	--	1	--
11	1	7	1	2	2	--
10	11	5	--	7	3	--
9	7	2	1	16	5	--
8	5	1	1	13	5	--
7	1	1	--	6	10	--
6	1	3	--	1	11	--
5	1	--	1	3	5	2
4	2	1	--	1	3	3
3	--	1	1	--	1	12
2	--	--	--	1	4	14
1	--	--	--	--	--	15
0	--	--	--	--	--	4

Table II

Percentage of AGREE Responses to All Statements
Identified with Philosophers of Science
for Individual Respondents

	Philosophers of Science					
	Carnap	Hempel	Kemeny	Lachman	Popper	None
Total Statements	18	19	22	12	15	7
Respondent	%	%	%	%	%	%
1	50.0	52.6	63.6	58.3	40.0	42.9
2	72.2	73.7	77.3	75.0	60.0	0.0
3	66.7	68.4	68.2	91.7	66.7	42.9
4	55.6	63.2	68.2	83.3	46.7	14.3
5	50.0	52.6	63.6	75.0	33.3	14.3
6	44.4	36.8	59.1	58.3	33.3	71.4
7	50.0	57.9	68.2	66.7	40.0	57.1
8	27.8	15.8	36.4	41.7	13.3	42.9
9	72.2	73.7	77.3	75.0	46.7	42.9
10	55.6	68.4	63.6	41.7	53.3	57.1
11	66.7	73.7	63.6	66.7	46.7	28.6
12	61.1	63.2	68.2	75.0	66.7	14.3
13	66.7	78.9	81.8	75.0	80.0	28.6
14	55.6	63.2	63.6	83.3	46.7	14.3
15	72.2	78.9	77.3	75.0	73.3	28.6
16	83.3	84.2	90.0	83.3	53.3	71.4
17	55.6	57.9	63.6	66.7	33.3	42.9
18	72.2	84.2	77.3	66.7	60.0	14.3
19	44.4	52.6	40.9	50.0	40.0	28.6
20	22.2	21.1	22.7	33.3	13.3	0.0
21	55.6	68.4	59.1	75.0	46.7	14.3
22	55.6	63.2	77.3	75.0	60.0	28.6
23	66.7	63.2	63.6	75.0	66.7	28.6
24	55.6	63.2	68.2	66.7	33.3	28.6

Table II - Continued

	Philosophers of Science					
	Carnap	Hempel	Kemeny	Lachman	Popper	None
Total Statements	18	19	22	12	15	7
Respondent	%	%	%	%	%	%
25	50.0	57.9	68.2	66.7	26.7	42.9
26	66.7	78.9	68.2	83.3	60.0	14.3
27	72.2	73.7	63.6	75.0	40.0	28.6
28	50.0	52.6	72.7	66.7	40.0	42.9
29	55.6	63.2	72.7	75.0	46.7	42.9
30	72.2	78.9	72.7	91.7	60.0	14.3
31	38.9	31.6	59.1	66.7	13.3	0.0
32	66.7	68.4	68.2	75.0	73.3	42.9
33	77.8	78.9	68.2	75.0	53.3	42.9
34	44.4	42.1	63.6	66.7	26.7	14.3
35	55.6	63.2	50.0	41.7	40.0	14.3
36	44.4	47.4	63.6	66.7	40.0	42.9
37	55.6	57.9	77.3	66.7	40.0	28.6
38	72.2	63.2	63.6	58.3	53.3	14.3
39	50.0	52.6	54.5	58.3	40.0	14.3
40	44.4	47.4	59.1	58.3	46.7	28.6
41	77.8	84.2	81.8	83.3	53.3	28.6
42	72.2	78.9	77.3	66.7	46.7	28.6
43	22.2	31.6	13.6	16.7	13.3	0.0
44	77.8	73.7	68.2	83.3	46.7	14.3
45	66.7	73.7	77.3	66.7	40.0	14.3
46	55.6	57.9	54.5	75.0	40.0	28.6
47	66.7	57.9	63.6	83.3	46.7	57.1
48	50.0	57.9	68.2	75.0	26.7	42.9
49	72.2	73.7	72.7	75.0	33.3	14.3
50	33.3	31.6	59.1	58.3	20.0	28.6

affiliation. However, this apparent lack of philosophic consistency exhibited by the teachers as a group could be the result of individual teachers holding philosophically different, but consistent, views. Consequently, each individual teacher's response data were examined seperately and the percentage of that individual's "agree" responses to all statements identified with each of the five philosophers was calculated. The results are reported in Table II and constitute a set of "philosophic profiles," one for each teacher. An examination of this table indicates that the individual teachers exhibited no greater degree of internal philosophic consistency than the teachers as a group.

Summary and Discussion

Wisconsin middle grade science teachers hold divergent opinions about the nature of laws and theories. Their views are frequently disparate, contradictory, and philosophically inconsistent. They agree most frequently with a Lachman model and least frequently with Popper, but do not decisively endorse any single philosopher's viewpoints. Individual teachers exhibit no greater degree of philosophic consistency than the teachers as a group.

Replication of the design of the current investigation

with varying populations of science teachers could, if results prove to be consistent, enable construction of a model of science teachers' conceptualizations of laws and theories. The model could then be used to determine the degree of congruency between viewpoints expressed in science curriculum materials and those held by the science teachers who use these materials.

The results of the current study also indicate that further attention should be directed toward the preservice and inservice training of science teachers relative to the nature of the scientific enterprise. Additionally, research needs to be conducted into the conceptualizations that science teachers identify with other terms that are subsumed under the broad "nature of science" topic. In light of the importance currently attached to "process" goals, philosophically-based investigations into the meanings that teachers associate with such processes as experimenting, observing, classifying, hypothesizing and many others are needed.

References

Carnap, Rudolf. Philosophical Foundations of Physics. New York: Basic Books, Inc., 1966.

Connelly, F. Michael. "Conceptual Structures in Ecology with Special Reference to an Enquiry Curriculum in Ecology." Unpublished doctoral dissertation, University of Chicago, 1968.

Hempel, Carl. Philosophy of Natural Science. Englewood Cliffs, New Jersey: Prentice-Hall, 1966.

Herron, Marshall D. "The Nature of Scientific Enquiry." School Review, 1971, 79, 171-212.

Kemeny, John. A Philosopher Looks at Science. Princeton: D. Van Nostrand Company, 1959.

Lachman, Sheldon. The Foundations of Science. New York: Vantage Press, 1960.

Popper, Karl. The Logic of Scientific Discovery. London: Hutchinson and Company, 1962.

Robinson, James T. "An Investigation of Selected Frameworks of Science." Unpublished doctoral dissertation, Stanford University, 1964.

Schwab, Joseph J. "What Do Scientists Do?" Behavioral Science, 1960, 5, 1-27.